

Information Request JS-NSTAR-1-4

On Page 5, Mr. Salamone discusses customer load patterns being driven by extreme weather conditions, claiming "Customer peak demands during these conditions exhibit very little diversity from their individual peak demands with diversity factor values ranging from 95 percent to 100 percent."

- A. Please provide an operable definition of "extreme weather conditions" and identify the hours since 1999 of the extreme weather conditions which meet this definition.
- B. For each of the hours identified in A, provide the total demand for each of the NSTAR Electric companies.
- C. For each NSTAR Electric customer with self generation, provide an Excel formatted spreadsheet showing.
  - 1. The loads during each of the hours identified in A.
  - 2. The individual peak demands for the same month as the identified hour.
  - 3. The metered energy for the same month as the identified hour.
  - 4. The individual peak demands for the same year as the identified hour.
  - 5. The metered energy for the same year as the identified hour.
  - 6. Calculated diversity factor.
- D. For each NSTAR Electric customer with a peak demand in excess of 100 KW and without self generation served under G-2, G-3, or T-2 tariff, provide an Excel formatted spreadsheet showing.
  - 1. The loads during each the hours identified in A.
  - 2. The individual peak demands for the same month as the identified hour.

3. The metered energy for the same month as the identified hour.
4. The individual peak demands for the same year as the identified hour.
5. The metered energy for the same year as the identified hour.
6. Calculated diversity factor.

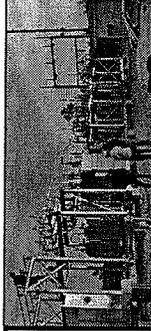
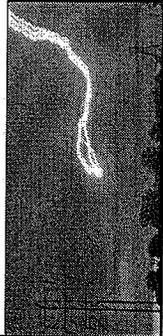
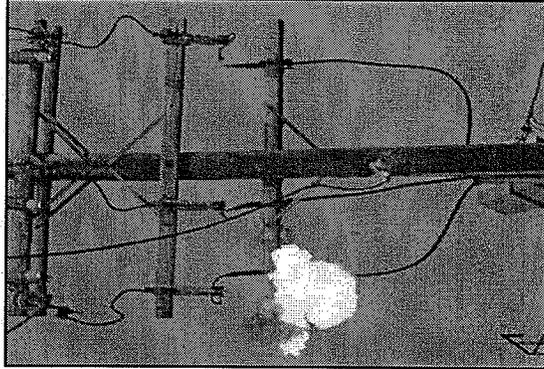
Response

The Company objects to this information request because it includes a false premise that makes it impossible to answer. Moreover, the information requested does not exist in the form requested and trying to provide such information would require an unduly burdensome special study that would not lead to relevant evidence. The question appears to misunderstand the application of an extreme weather forecast. The attached PowerPoint presentation (Attachment JS-NSTAR-1-4) provides an overview of the procedures NSTAR Electric has developed for producing an extreme weather load forecast for each substation in its system. The process involves a determination of the weather extreme conditions that could reasonably occur over a forecast period and the sensitivities of system loads to these conditions. As the presentation indicates, it was found that a once-in-ten-year weather extreme occurrence is a reasonable basis for developing a forecast of system loads and for designing an electric distribution system. This means that only a single occurrence of these conditions is expected to be encountered over a given ten-year period. This is not a routine condition and, as indicated in the presentation for both 2001 and 1999, actual conditions were slightly less severe than the design conditions for which the extreme weather conditions are defined. Accordingly, there are no hours that an extreme weather condition was exceeded as the conditions were not fully met for the years requested.

June 20, 2002

**NSTAR**

**Sub Regional Forecast  
Review & Weather Planning  
Criteria and Adjustment**



# Agenda

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- Introduction / Background
- Forecast Model Development
- Forecast Procedure/Methodology
- Sub Regional Forecast Review
- Weather Planning Criteria
- Weather Adjustment Model Development
- Weather Adjustment of Sub-Regional Forecast
- Questions

# Introduction / Background

## Introduction / Background

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- The principal objective of the spatial load forecast is the allocation of overall NSTAR-North forecast load growth among substations based on spatial characteristics
- The spatial forecast is based on the overall NSTAR econometric forecast (not a substitute for the overall NSTAR forecast)
- The results of the spatial forecast are predicted non-coincident substation peak loads for each substation in the model

## **Introduction / Background**

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- Spatial forecasts are useful in identifying long term growth trends that may not be obvious using different forecasting methods or a shorter forecasting horizon
- Forecasts were developed for three scenarios:
  - Base Case (Including Internet Hotel Load)
  - Alternate #1 (Probable Spot Load Effects)
  - Alternate #2 (Possible Spot Load Effects)

## **Introduction / Background**

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- Identification of weather criteria for planning is important in defining “base conditions” for system planning.
- Weather criteria differ across the NSTAR area due to topographical/geographical features (e.g. coastal areas).

## **Introduction / Background**

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- Weather adjustment of loads is important to ensure the system is planned to serve load that may occur in the event of extreme weather conditions.
- Weather adjustment is performed on a “per substation” basis to account for the variation in weather sensitivity among substations.

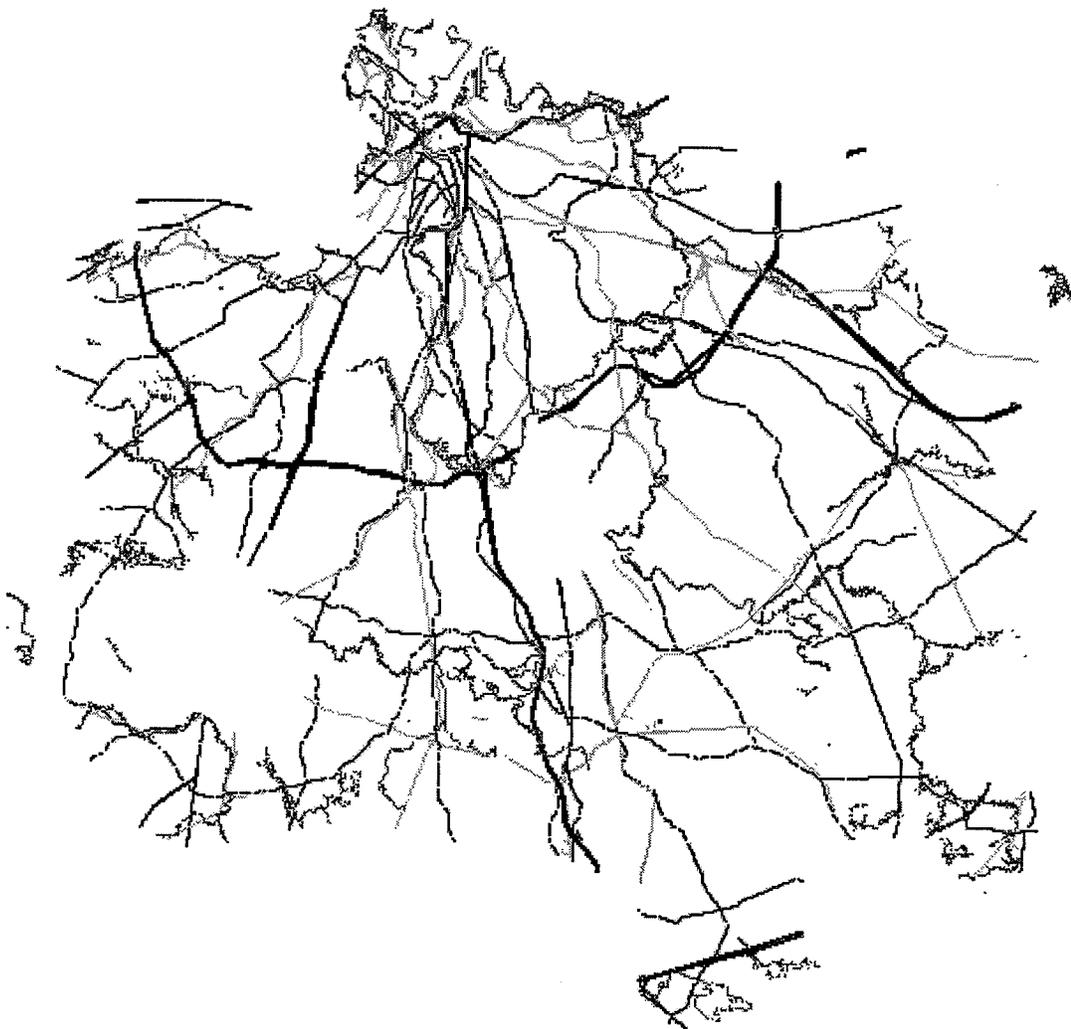
# Forecast Model Development

# Forecast Development Steps

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- Infrastructure Modeling
- Existing Land Use Modeling
- Future / Zoned Land Use Modeling
- Substation Area Modeling
- Calibration / Revision

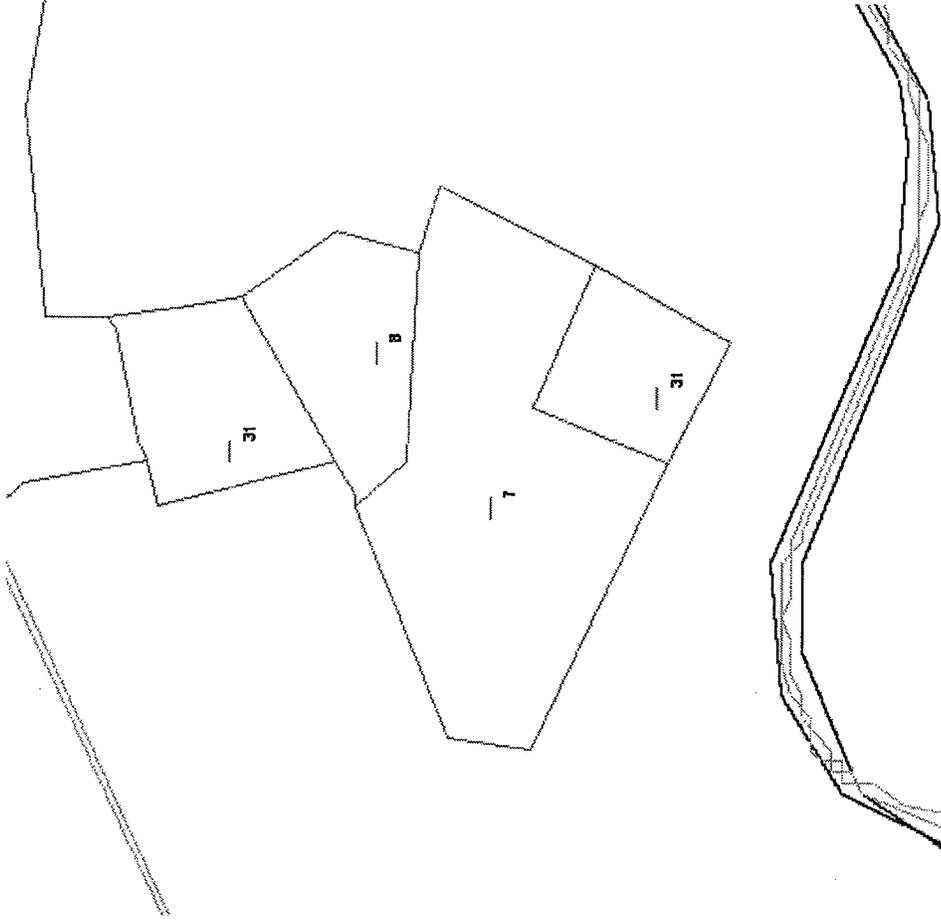
# Infrastructure Modeling



- Infrastructure was imported from NSTAR GIS
- Infrastructure included:
  - interstates
  - major roadways,
  - railroads
  - waterways

# Land Use Modeling

- Existing and future land use was modeled based primarily on land use and zoning information supplied by NSTAR.
- The land use and zoning data was “digitized” for use in the spatial load forecast.

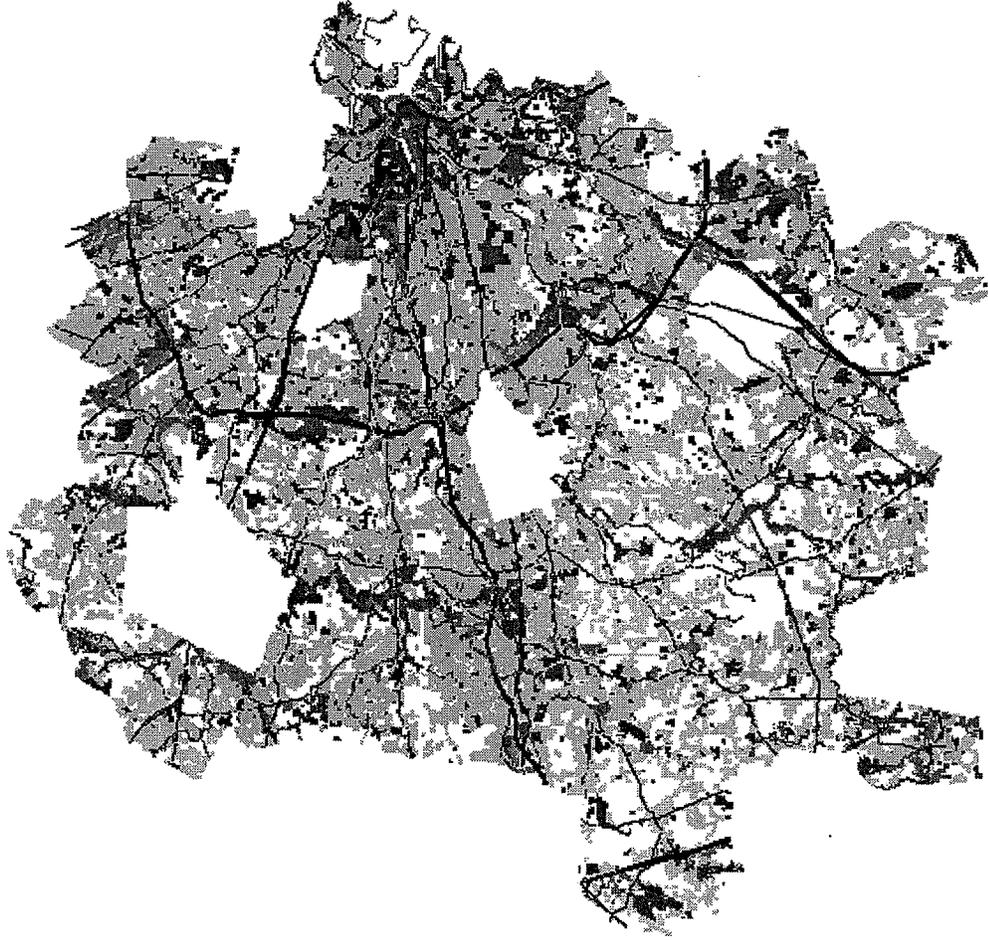


# Existing Land Use Modeling

- Existing land use was modeled based on NSTAR GIS data and satellite images.

- Key:

- Residential - Blue
- Commercial - Pink
- Industrial - Gray
- Green - Parks

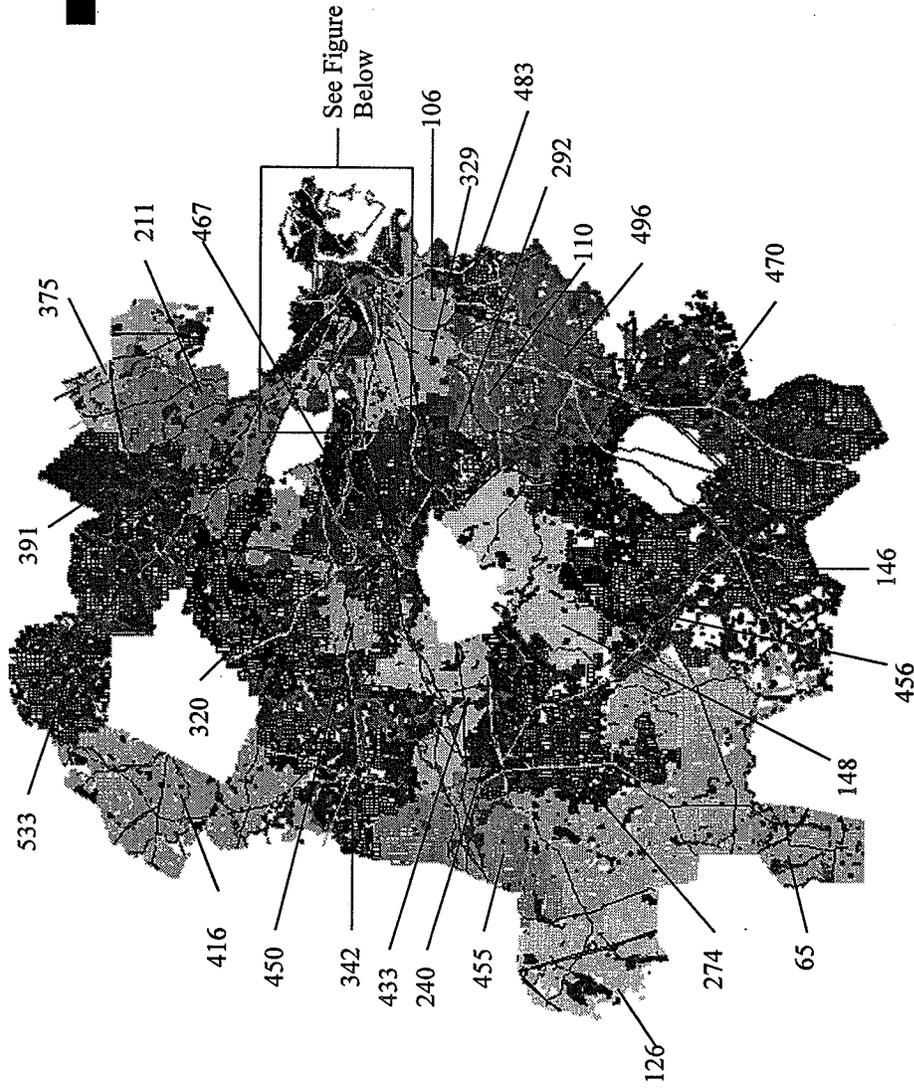


## **Future / Zoned Land Use**

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- Zoning data was digitized into the model in a manner similar to the existing land use.
- Modeled zoning was checked by NSTAR for accuracy and adjustments to the model were incorporated.
- NSTAR provided guidance for modeling of redevelopment areas (South Boston, Downtown, Brighton).

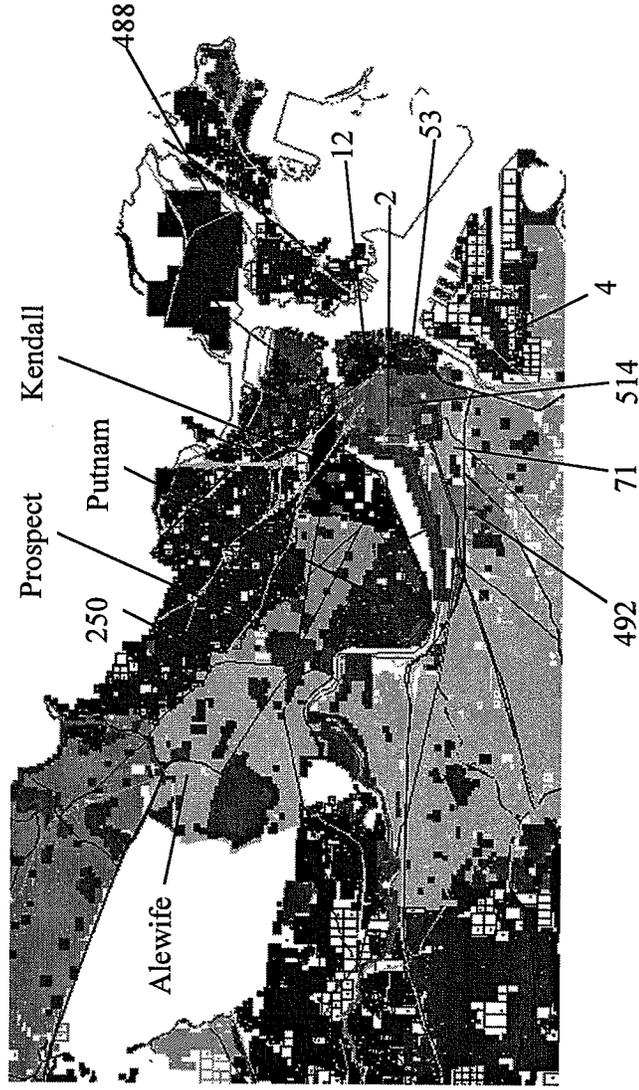
# Substation Area Modeling



- The capacity, loading and area served by each bulk substation in the NSTAR-North region was modeled to allow calibration to actual substation peak loads and “roll up” forecast results.

# Substation Area Modeling

- Substation areas are approximated in the model, since areas with interlaced or overlapping feeders would make assignment of growth to a particular substation nearly impossible.



## **Calibration / Review**

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- The load densities of the existing and future development served by each substation were calibrated to the 1999 substation peak load.
- This calibration provides the link between land use and load levels for the forecast.
- The model was reviewed by the NSTAR Coordinating Team to ensure a reasonable representation of the existing development and zoning.

# Methodology

# Methodology

- The load forecast attempts to allocate loads based on proximity of different infrastructure elements and development.

Parameter	Development Type		
	Residential	Commercial / Office	Industrial
Close to Railroad	-1.0	-0.5	1.0
Adjacent to Highway	-0.66	1.0	-0.1
Close to Highway	1.0	1.0	0.5
Close to Industry	-1.0	-0.5	1.0
Close to Water	0.5	0.0	0.5
Close to Major Intersection	-1.0	1.0	-1.0
0.5 Mile Res. Total	1.0	-0.2	-0.5
3.0 Mile Res. Total	-0.33	1.0	-0.16
1.0 Mile Comm. Total	-0.16	0.5	0.0
2.0 Mile Ind. Total	-1.0	-0.5	1.0

# Methodology



- A center of attraction for growth (or pole) is determined.
- Impact of the pole decreases with distance from the center.
- Fundamental to focus growth around downtown.

Development Factor (at center of effect)	Development Type	
	Residential	Commercial / Office
0.75	1.5	0.75

# Methodology

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- The overall spatial forecast matches the overall corporate forecast provided by the NSTAR Budgeting and Forecasting Department.
- Preference factors for each small area are added and growth of individual load areas is sequenced based on the total preferences.
- This results in a smooth growth curve since each load area represents a relatively small amount of load.

## **Probable / Possible Spot Loads**

- The alternate scenarios include large ( >1 MW) spot loads identified by NSTAR
- The spot loads are modeled with fixed development dates.
- The spot load additions result in greater absolute growth (i.e. future growth rates are applied to the sum of the base case forecast load and the spot loads)

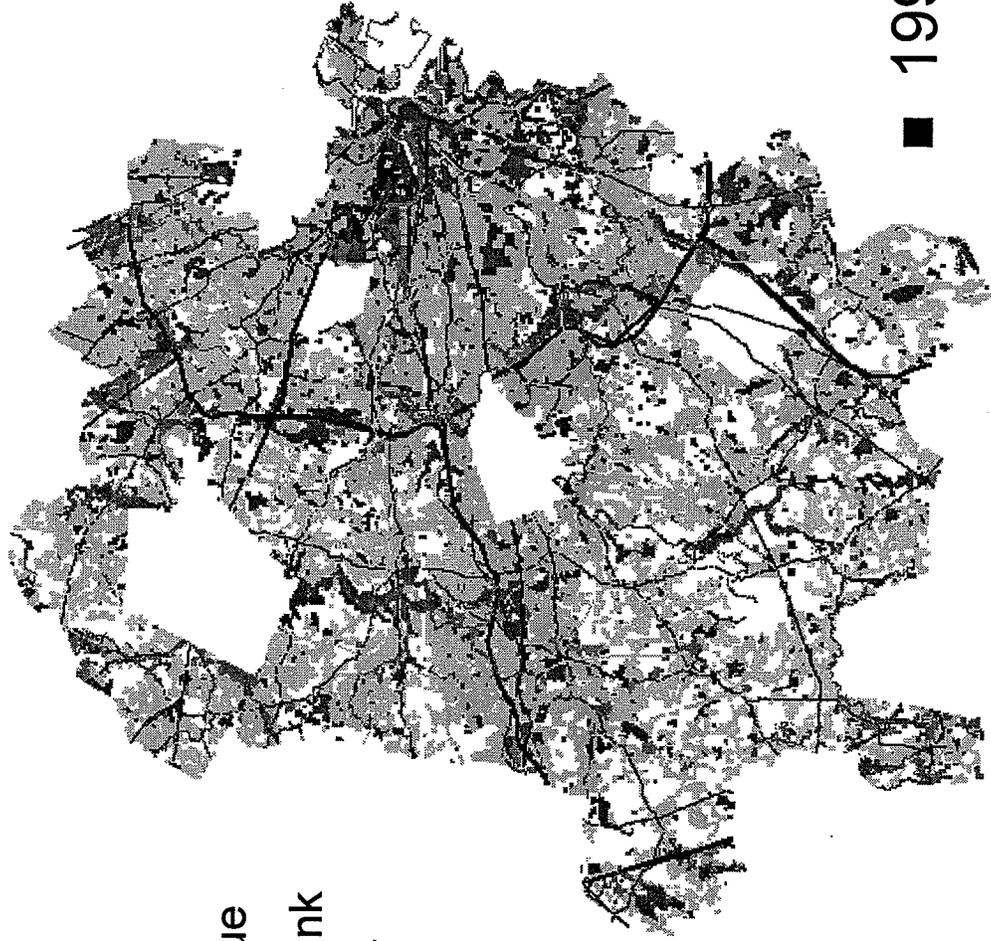
## **Scenario Relationship to Corporate Forecast**

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- The base case scenario tracks the corporate forecast.
- The alternate scenarios include additional major spot loads to provide a measure of forecast sensitivity to major load development.
- “Double counting” minimized by forecast adjustment to track corporate forecast.

# Sub Regional Forecast Review

# Sub Regional Forecast Review



Residential - Blue

Commercial - Pink

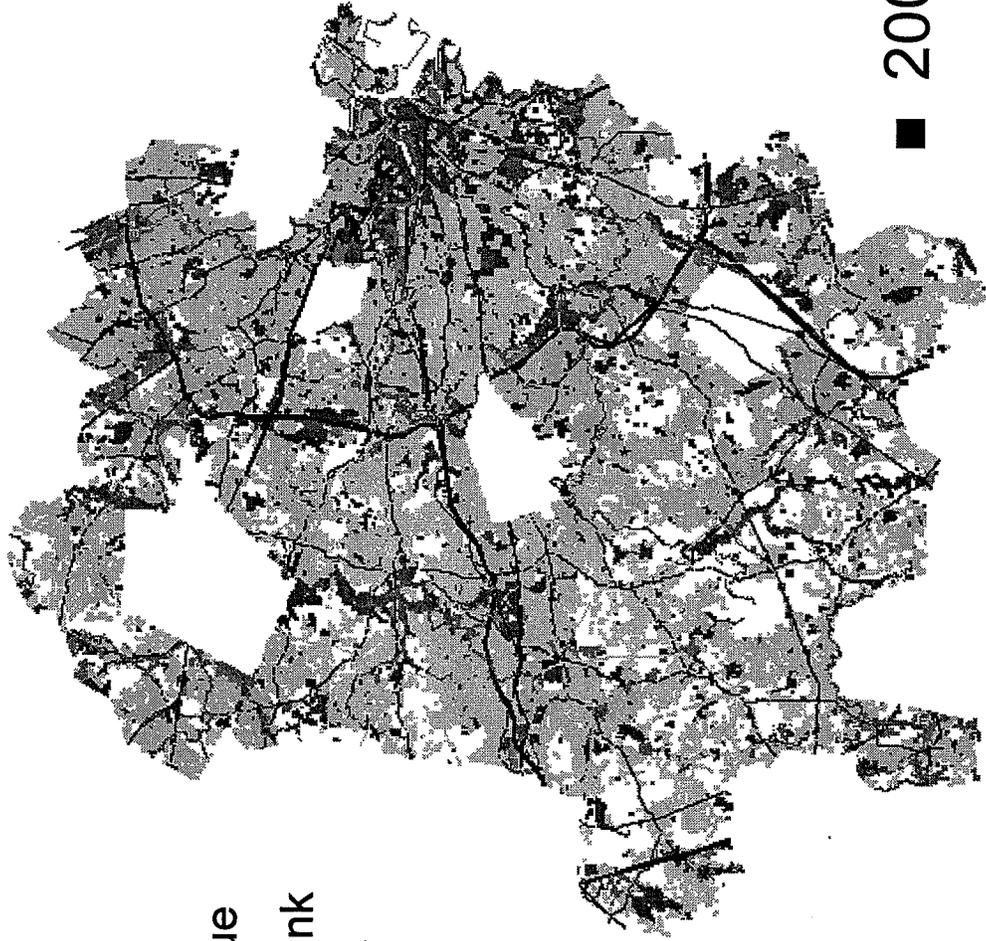
Industrial - Gray

Green - Parks

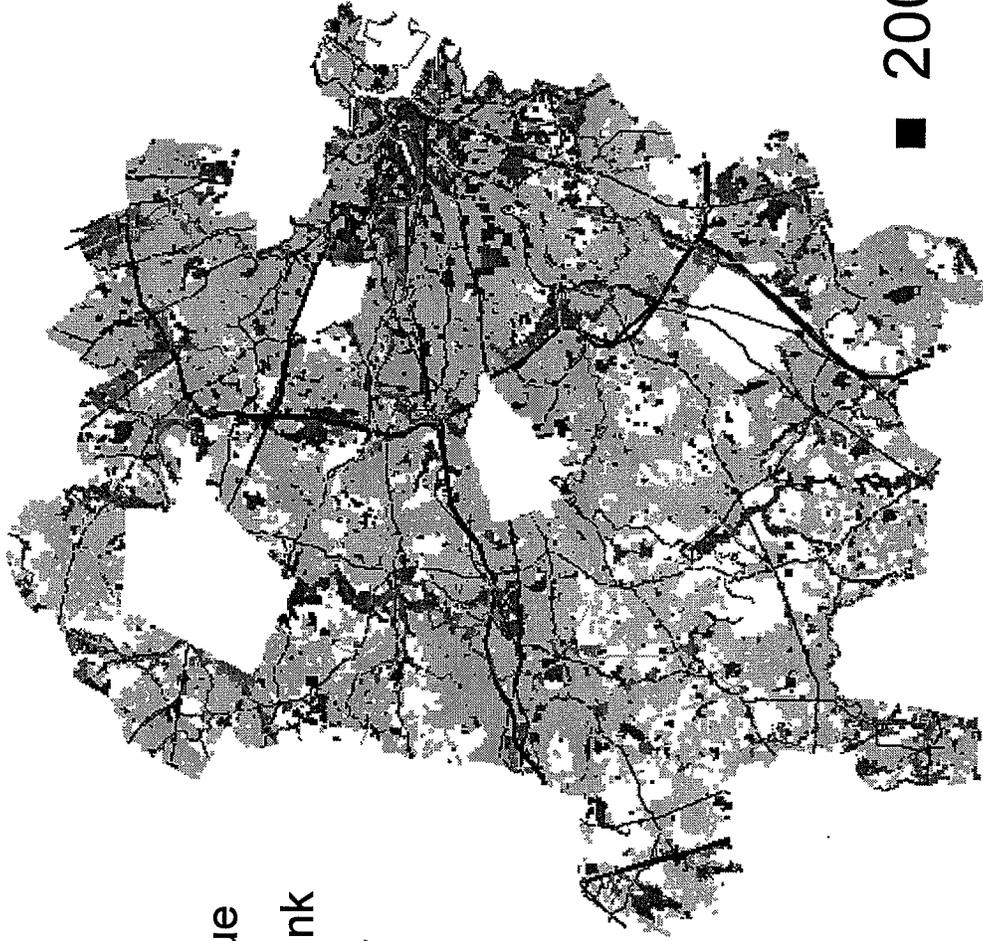
■ 1999 Land Use

# Sub Regional Forecast Review

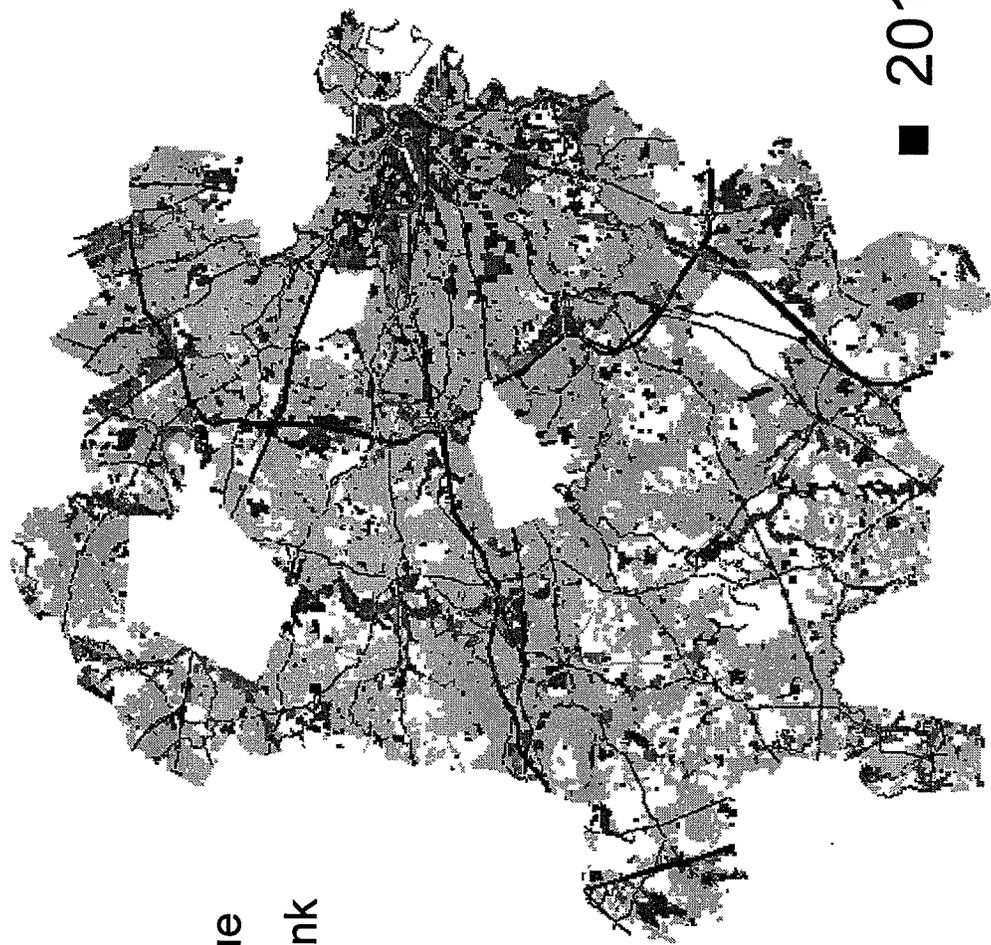
Residential - Blue  
Commercial - Pink  
Industrial - Gray  
Green - Parks



# Sub Regional Forecast Review



# Sub Regional Forecast Review



Residential - Blue

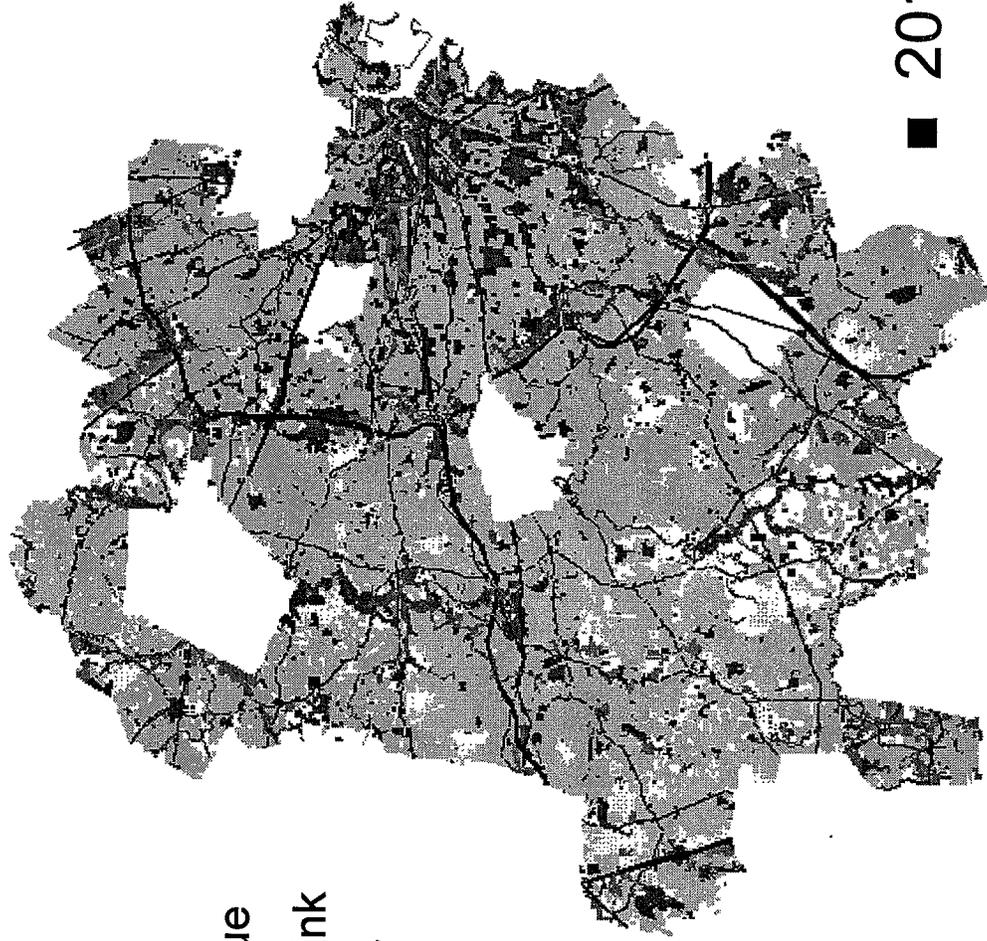
Commercial - Pink

Industrial - Gray

Green - Parks

■ 2010 Land Use

# Sub Regional Forecast Review



- Residential - Blue
- Commercial - Pink
- Industrial - Gray
- Green - Parks

■ 2015 Land Use

## Forecast Use

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- Forecast results incorporated into 2001 ten year planning process:
  - Provide “locational” aspects of load growth
  - Identify potential long range trends
  - Allow spot loads to be “backed out” (e.g. internet hotels)
  - Tie to overall corporate load growth forecast

# **Weather Planning Criteria Definition and Weather Adjustment**

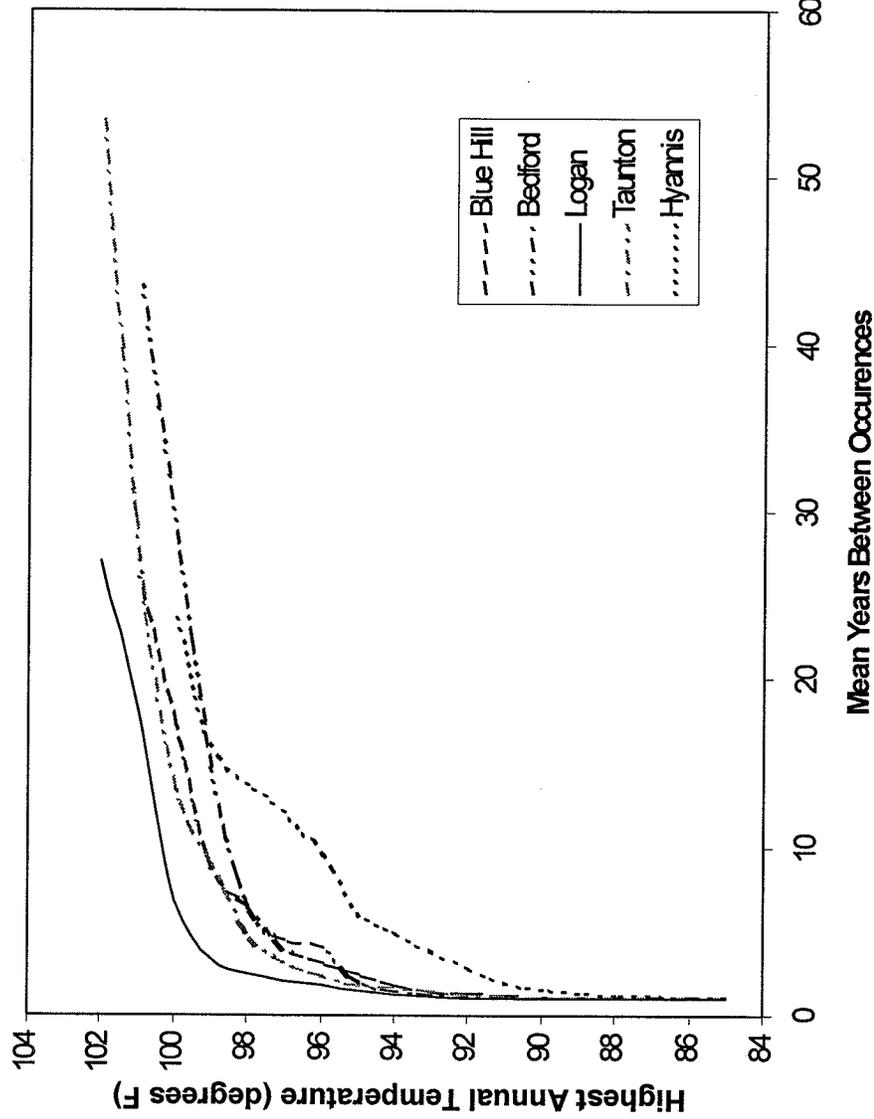
# Weather Planning Criteria and Adjustment

- Reasons for defining weather planning criteria and a weather adjustment procedure include:
  - Define conditions to which system is planned
  - Provide a consistent basis for forecast loads
  - Consideration of extreme weather directed in DTE 01-65
  - Compare measured loads from mild / hot years
- Three subsequent topics:
  - Weather Planning Criteria
  - Weather Adjustment Model Development
  - Weather Adjustment of Sub-Regional Forecast

# Weather Planning Criteria

# Weather Analysis

- Weather conditions plotted versus occurrence frequency



## Purpose:

Emphasize "saturation" of weather conditions beyond one-in-ten.

Illustrate difference between weather stations.

# Recent Weather

- General deviations from average summer weather:
  - 1999 – Above mean
  - 2000 – Below mean
  - 2001 – Above mean

## Boston – Logan Weather

	Max Temp	3 Day Avg Max Temp	CDD	3 Day Total CDD	5 Day Total CDD
Average	96.2	93.1	19.8	52.8	79.0
Std Dev	2.8	3.0	2.8	8.2	13.2
1999	98	96.7	24.5	58.5	83.5
2000	92	88.0	16.0	44.0	64.0
2001	97	93.0	23.0	57.5	92.0

# Recommended Criteria

- One-in-ten criteria are recommended

	Max Temp	3d Avg Max Temp	CDD	3d Total CDD	5d Total CDD
Bedford	99	97	20	54	83
Blue Hill	100	97	22	56	86
Hyannis	97	94	20	52	81
Logan	101	98	25	65	97
Taunton	100	99	21	53	82

- One-in-ten criteria recommended because
  - beyond the “knee” of the frequency of occurrence curves
  - more severe than 2001 / slightly more severe than 1999
  - approximately two standard deviations from mean

# **Weather Adjustment Model Development**

## **Model Variables Considered**

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- Weather Variables
  - Maximum Daily Temperature (peak day and three day average)
  - Min. Daily Temperature
  - Cooling Degrees (peak day, three day and five day running totals)
- Non-Weather Variables
  - Day of Week
  - Week of Season

## **Data Selection for Model Development**

- Models developed for each substation for 1999, 2000 and 2001
  - summer data only - June 1<sup>st</sup> through September 15<sup>th</sup>
  - used 10% of days with the highest summation of non-coincident substation loads
- Selection Rationale
  - “high” load days capture peak load weather dependence
  - avoid random “noise” / non-linearities at lower load levels

# Model Development

- Fourteen models were screened for statistical “fit” across the population of NSTAR substations for 1999, 2000, 2001.

Linear Single Variable	Non-Linear Single Variable	Linear Two Variable
$Load = a_1 T_{\max 0} + a_0$	$Load = a_1 T_{\max 0}^X + a_0$	$Load = a_2 T_{\max 0} + a_1 T_{\max 3d} + a_0$
$Load = a_1 T_{\max 3d} + a_0$	$Load = a_1 T_{\max 3d}^X + a_0$	$Load = a_2 T_{\max 0} + a_1 CDD_{3d} + a_0$
$Load = a_1 CDD_0 + a_0$	$Load = a_1 CDD_0^X + a_0$	$Load = a_2 T_{\max 0} + a_1 CDD_{5d} + a_0$
$Load = a_1 CDD_{3d} + a_0$	$Load = a_1 CDD_{3d}^X + a_0$	$Load = a_2 T_{\max 0} + a_1 T_{\max -1} + a_0$
$Load = a_1 CDD_{5d} + a_0$		$Load = a_2 T_{\max 0} + a_1 CDD_{-1} + a_0$

# Model Screening

- Single variable models based on the five day running total of cooling degree days consistently had the highest coefficient of determination ( $R^2$ ) among single variable models.

## Single Variable Model Performance

Model	NSTAR North			NSTAR South		
	1999	2000	2001	1999	2000	2001
$Load = a_1 T_{\max 0} + a_0$	0	0	0	0	0	0
$Load = a_1 T_{\max 3d} + a_0$	0	0	0	0	0	0
$Load = a_1 CDD_0 + a_0$	11	1	1	3	2	10
$Load = a_1 CDD_{3d} + a_0$	3	3	8	1	10	8
$Load = a_1 CDD_{5d} + a_0$	23	33	28	25	17	11

# Model Screening

- Models based on the combination of the peak day temperature and the prior day cooling degrees (R<sup>2</sup>) among two variable models.

Two Variable Model Performance

Model	NSTAR North			NSTAR South		
	1999	2000	2001	1999	2000	2001
$Load = a_2 T_{\max 0} + a_1 T_{\max 3d} + a_0$	7	3	2	6	3	5
$Load = a_2 T_{\max 0} + a_1 CDD_{3d} + a_0$	0	0	0	0	0	0
$Load = a_2 T_{\max 0} + a_1 CDD_{5d} + a_0$	0	0	0	0	0	0
$Load = a_2 T_{\max 0} + a_1 T_{\max -1} + a_0$	2	6	2	11	0	3
$Load = a_2 T_{\max 0} + a_1 CDD_{-1} + a_0$	28	28	33	12	26	21

## Recommended Model

$$Load = a_2 T_{\max 0} + a_1 CDD_{-1} + a_0$$

- Regression model parameters ( $a_0, a_1, a_2$ ) are developed for each substation based on load and weather data for the 10% of summer days with the greatest loads.
- Regression model used to determine weather adjustment parameters.

## Model Use

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- Adjustment factors determined based on peak load estimates computed from extreme and actual weather conditions.

$$\text{Adjustment Factor} = \frac{\text{Extreme Weather Peak Load Estimate}}{\text{Actual Weather Peak Load Estimate}}$$

- Adjustment factors applied to actual peak load to determine weather adjusted peak loads.

$$\text{Weather Adjusted Peak} = \text{Adjustment Factor} * \text{Actual Peak}$$

## Model Use Summary

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- The procedure for weather adjustment of substation loads for a given year is summarized in the steps below:
  1. Determine regression model parameters
  2. Compute estimated peak load based on regression model and actual weather conditions
  3. Compute estimated extreme weather peak load based on regression model and extreme weather conditions.
  4. Compute weather-adjustment factor.
  5. Apply adjustment factor to actual peak load.

# **Weather Adjustment of Sub-Regional Forecast**

## **Sub-Regional Forecast Adjustment**

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- Sub-regional forecast results can be weather adjusted based on:
  - 2001 Regression Model Parameters
    - reflect the most recent weather sensitivity
  - 1999 Extreme Weather Conditions
    - reflect “worst case” 1999 weather
- Sub-Regional Forecast Adjustment Procedure
  - 1) Remove “spot” loads from forecast
  - 2) Apply adjustment factors to forecast (with “spot” loads removed)
  - 3) Add “spot” loads to adjusted forecast

## **Overall Use of Adjustment / Forecast**

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- **Sub-Regional Forecast - update every 4-5 years**
  - revisions to corporate growth forecast
  - substation capacity additions and service area changes
- **Weather Adjustment – use on an annual basis**
  - compute / apply each year to assess load growth
  - compare weather adjusted actuals / forecasts
  - compare adjustment factors for major changes

# Questions

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